Thermal Fracturing, Underwater Ambient Noise Measurements, and Modeling

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LONG-TERM GOALS

The long term goals is to understand thermally-generated ice stresses, cracking, and the resulting under-ice ambient noise and develop a physically-based model for these processes.

OBJECTIVES

Near the SHEBA field operation, collect under-ice noise data at those frequencies associated with the thermal fracturing of pack ice. We wish to ascertain those relationships between the thermal forcing of floes, the generation of stresses in the floes as a result of the thermal forcing, the eventual fracturing of ice in tension in the floes, and the generation and propagation of acoustical energy from the fractures into the water column. The SHEBA field data and associated under-ice noise is being utilized in determining the relationships in these processes.

APPROACH

Develop an inexpensive system for making unmanned, long-term under-ice noise measurements in the Arctic with satellite telemetry of the data, build three of these systems and deploy them at remote sites near the SHEBA field operation, and acquire the data and include it in the SHEBA database. Continue our studies considering stresses in pack ice, concentrating on thermally-induced stresses but also examining motion-induced stresses. Utilize the SHEBA and other data to further verify and refine the model of thermally fracturing in pack ice.

WORK COMPLETED

Two of the under-ice noise measurement systems where built and successfully deployed during the first two weeks of October 1997. The systems are located about 50 km from the main SHEBA camp. The two systems have been working flawlessly.

Two papers on stresses in floes were generated and published in the *J. Geophys. Res*. A paper on the ambient noise model has been submitted to the *J. Acoust. Soc. Amer*. The thermal stress model was adapted to the conditions during SHEBA in terms of surface and bottom thermal forcing as well as spatial and temporal variations of snow cover. The conditions for SHEBA have been considered by comparing model-predicted temperatures in the ice with observed under-ice noise data. Investigations as to thermal fracturing and the associated noise over a broad range of frequencies have been initiated.

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Fig. 1. One of the remote hydrophones stations deployed 50 km from the SHEBA main camp. On the post are four solar panels, a GPS antenna, and an ARGOS antenna. The box contains the data acquisition computer, anti-aliasing filters, and other electronics. The hydrophone is passed through the ice directly next to the electronics box. A stress sensor is deployed 10 m away. All cables run through conduit to protect them from animal bites.

RESULTS

The under-ice noise measurements systems have collected third octave ambient noise data from 50 to 3200 Hz, noise statistics, ice stress, and system support information every hour and transmitted these data back via Argos. Fig. 1 shows one of the systems at the time of installation. The data are being included in the SHEBA database. The systems were rediscovered during the fall of 1998, and one system was redeployed to collect another year of data. The systems have solar panels to recharge the batteries during the summer. The results to date indicate that they can run indefinitely with this power system.

The thermal stress model was adapted to the conditions during SHEBA in terms of surface and bottom thermal forcing as well as spatial and temporal variations of snow cover. However, without the observed ice stresses (which should be available from CRREL during November 1998), porosities, and salinities (which should be available from CRREL during February 1999), the ambient noise model cannot be exercised for the SHEBA conditions. While waiting for the observations from SHEBA, we

have furthered studied the CEAREX under-ice noise data with the ambient noise model. Specifically, we are considering how the model applies to various frequencies as well as actual source levels for a given fracture.

The conditions for SHEBA have been considered to some degree by comparing model-predicted temperatures in the ice with observed under-ice noise data. In Fig. 2 we show the ice temperature variations at different levels (coldest being closest to the surface of the floe) along with the under-ice noise at 1000 Hz. As predicted by the thermal stress model, there is no consistent correlation between temperature and the noise as a result of the non-linear mechanics of thermally-generated fracturing is pack ice.

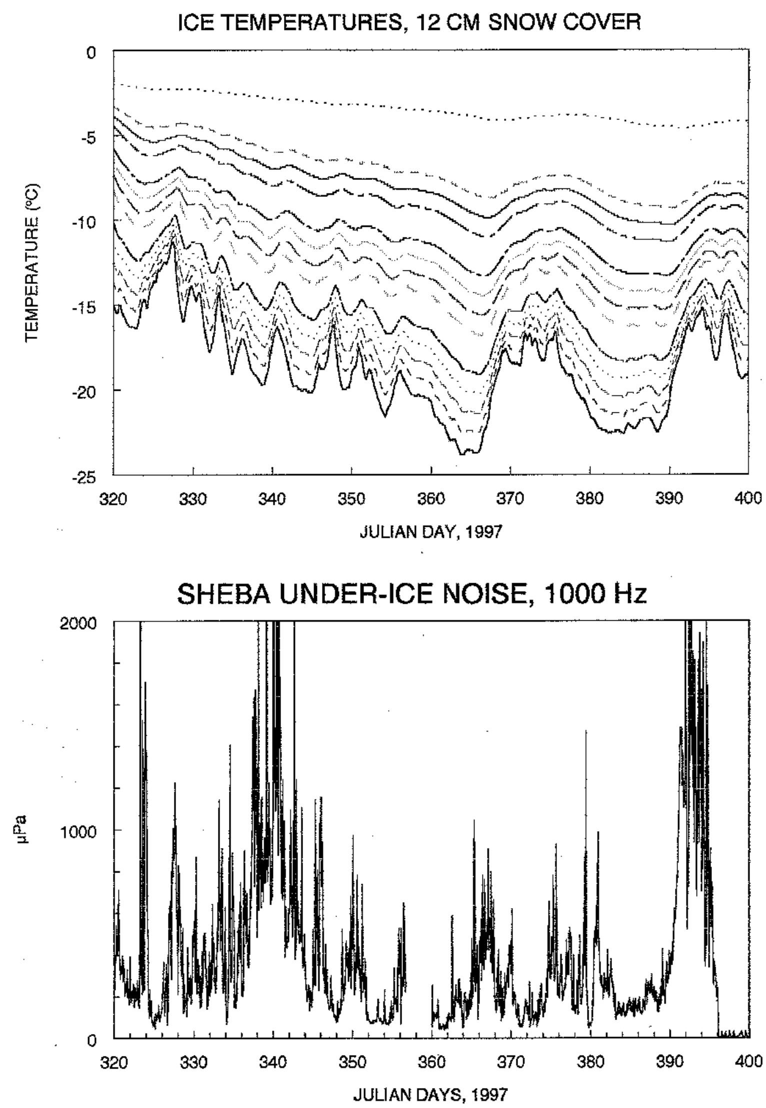

Fig. 2. Model-predicted ice temperature variations at different levels (coldest being closest to the surface of the floe) along with the corresponding under-ice noise at 1000 Hz collected by the system shown in Fig. 1.

IMPACT/APPLICATION

One primary impact of this project is the development of a system which will allow for the long-term, economical monitoring of under-ice noise in the Arctic. Applications would include monitoring times of ice freeze-up and melt as well as the consideration of heat fluxes as determined from under-ice noise episodes at specific frequencies. Eventually, assimilation methods may be developed based on observed under-ice noise for heat flux events over the arctic ice pack to insure ocean-ice-atmospheric models are operating properly.

The second primary impact of our work is utilizing the thermal stress model and its associated under-ice noise model to predict noise fields throughout the Arctic Ocean. This would provide the fleet with far more sophisticated capabilities in determining the spatial and temporal variations of under-ice noise.

TRANSITIONS

A proposal has been submitted to ONR to transition the thermal mechanical computer model and the under-ice noise computer model to the next generation forecasting model for ice covered areas in the northern hemisphere (PIPS 3.0).

RELATED PROJECTS

1 - Products from the data collection part of the project are being disseminated to all investigators involved with the SHEBA project.

2 - Topics related to stress within floes are being coordinated with scientists within CRREL (J. Richter-Menge, W. Tucker).

PUBLICATIONS

Lewis, J. K., 1997: Thermal stressing of pack ice. In *Proc. of the 7th Int'l. Offshore and Polar Eng. Conf.*, Honolulu, May 25-30, 1997. Int'l. Soc. Offshore and Polar Eng., 394-401.

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